This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

16521.d.1

6000458100

16521 d. 1.

UNIVERSITY OF EDINBURGH
ZOOLOGICAL LABORATORY.

DIRECTIONS FOR THE EXAMINATION

OF

AMŒBA, PARAMŒCIUM, VORTICELLA, HYDRA, LUMBRICUS, HIRUDO, ASTERIAS AND ECHINUS.

BY

J. COSSAR EWART, M.D.,
REGIUS PROFESSOR OF NATURAL HISTORY IN THE UNIVERSITY OF EDINBURGH,

AND

J. DUNCAN MATTHEWS,
DEMONSTRATOR OF ZOOLOGY IN THE UNIVERSITY OF EDINBURGH.

EDINBURGH:
JAMES THIN, PUBLISHER TO THE UNIVERSITY.
1884.

C 16521. d. 1

BODLEIAN LIBRARY
1 JAN 85
OXFORD.

AMŒBA.

Amœbæ are often found amongst the deposits of fresh water pools. When a small quantity of the material containing Amœbæ is introduced into a small glass aquarium, and some fresh water added, a thin film usually appears on the surface of the water. This film, when examined, will be found to be composed chiefly of small organisms, some of which are likely to be amœbæ.

Take by means of a pipette a small portion of the film, and allow a drop to fall on a glass slide. Lay a narrow strip of moistened writing paper near to the drop, and apply a covering glass so that one edge rests on the paper. Look for an Amœba with a low power, and then examine with a high power, noting that it consists of an irregular shaped central portion from which blunt processes (pseudopodia) of various sizes, project, and that when active the form of the body and processes are constantly changing.

A. Observe—

1. That the body consists of—
   (*a*) A central mass of granular protoplasm (endosarc) which extends into some of the pseudopodia, and usually contains a nucleus, a contractile vacuole, and food particles.
   (*b*) A thin almost transparent outer film (ectosarc) which contains few granules.
2. The change in form, the appearance and disappearance of the pseudopodia, and the movements of the granules. Note that the pseudopodia seem at first to consist only of ectosarc, but that as some of them increase in size the granular endosarc flows into them, and further that a pseudopodium may throw out new processes, and then advance, dragging, and ultimately completely absorbing the body and processes behind it.

B. Draw an Amœba at intervals of one or two minutes to show the changes of form, and indicate by arrows the directions of the currents of granules.

C. Examine—

1. The food particles, and note that they usually lie at first in a small quantity of water (food vacuole), and that the food may consist of minute plants or animals, and that in addition to food there are often grains of sand and other substances. Study the process of ingestion of the food particles, and the expulsion of the non-nutritious particles, and note that they enter or escape from any part of the surface.
2. The contractile vacuole, if visible, and watch its pulsations.
3. The nucleus which may be made more distinct by adding a drop of acetic acid to the preparation.

D. Add to one of the drawings the nucleus, the contractile vacuole, also the food vacuoles, and any foreign substances which may be present.

E. Look for encysted Amœbæ and for Amœbæ in process of division by transverse fission.

PARAMŒCIUM.

Paramœcium, Stentor and other ciliated infusoria are usually abundant in stagnant water. Opalina is often found in the rectum of the frog and newt.

Examine a drop of water containing Paramœcia with a low power and observe that they swim rapidly by means of their cilia, and that as they glide along they usually rotate on their longitudinal axis so as to show distinctly at intervals the mouth and pharynx on the ventral aspect.

A. Arrange a few fibres of fine cotton-wool over the drop, apply a covering glass, and examine with a higher power—

1. The Ectosarc.

Note (*a*) The thin cuticular layer perforated for the cilia.

(*b*) That the cilia form an almost uniform layer except in the region of the mouth where they are somewhat irregular and longer.

(*c*) The striated layer, the lines running nearly longitudinally.

(*d*) The two dorsally placed contractile vacuoles, from which several canals radiate—observe the rhythmical contractions of the vacuoles.

(*e*) The trichocysts; if not visible, they should be afterwards looked for, when acetic acid or some staining solution has been added.

2. The Endosarc.

Note (*a*) The granules moving in a definite direction.

(*b*) The nucleus with a nucleolus at its side—may not be visible until acetic acid is added.

(*c*) The food entering the endosarc from the pharynx and following the same course as the granules, the food particles lying at first in food vacuoles, but at a later stage in contact with the protoplasm.

(*d*) That the undigested portions of food escape by an anal aperture which usually appears some distance from the mouth.

B. Some of the Paramœcia may be fed with carmine, to show better the course of the circulation of the food particles, while others should be treated with acetic acid or stained with majenta, to show the nucleus, nucleolus, and trichocysts.

C. Examine with the low power and note if any of the Paramœcia are in contact with each other (conjugating) or in process of division by transverse fission.

D. Make a diagram of Paramœcium, showing all the structures referred to, and draw any other Infusoria that may be present in the preparation.

VORTICELLA.

Vorticellidæ are found both in fresh and salt water, adhering to plants, insects, &c., and when present in considerable numbers appear to the naked eye as little white tufts.

A. Remove a small piece of weed to which the Vorticellæ are attached, place in a drop of water on a slide, lay a piece of moistened writing paper near the weed, and apply a covering glass. Examine with low power, and note—

1. That the colony is composed of a number of individuals, each of which has a bell-shaped body, supported at its narrow end on a stem.
2. That this stem is constantly being retracted in a spiral form.
3. That during retraction of the stem, the body assumes a spherical form by the margin being bent closely inwards.
4. In addition look for—
   - (*a*) Specimens in process of budding.
   - (*b*) The small free swimming buds.
   - (*c*) The buds conjugating with adult fixed forms.
   - (*d*) Specimens in process of division by longitudinal fission.
   - (*e*) The half which becomes free, noting the posterior circlet of cilia which exists during its free-swimming stage.

B. Examine under high power, and notice—

1. That the bell has the margin bent outwards, forming a thickened edge (the peristome), and that it is vertically striated near the base.
2. That this peristome bears cilia.
3. That there is a ciliated disk-shaped portion—the epistome—filling up most of the mouth of the bell.
4. That at one point a space—the vestibule—is left between the peristome and epistome, and that there is a narrow pharynx continuous with the vestibule.
5. The stem, consisting of—
   - (*a*) An outer generally straight sheath, and
   - (*b*) A central striated portion, which has a slight spiral form within the outer sheath.
6. That on irritation the epistome is retracted, while the peristome is folded closely over it, so that the body assumes a rounded form, which is followed by the retraction of the body by the stem throwing itself into a spiral form.
7. That the body consists of cuticle, clear ectosarc, and granular endosarc.
8. The contractile vacuole near the upper edge of the bell.
9. That food vacuoles are present, and that they circulate slowly down one side and up the other.

C. Place a few particles of powdered carmine near the vorticellæ and notice that the cilia sweep them into the vestibule, near the bottom of which they are aggregated into a food vacuole.

D. Add to the preparation acetic acid or a staining fluid, and note the horse-shoe-shaped nucleus.

HYDRA; *Hydra viridis or H. fusca.*

Examine a living hydra with the naked eye or with a pocket lens, and note the cylindrical body with one end attached by means of a disc (foot), and the other surrounded by long active tentacles six to ten in number. Observe that the body changes its form, being sometimes elongated with all the tentacles extended, while at other times it is contracted to form a short thick column with the tentacles reduced to rounded nobs. Observe, further, that when elongated, the tentacles move about apparently in search of food, and that when small crustacea, &c., are secured they are conveyed to the oral aperture situated in the centre of the oral cone. If there are any buds present, note what stage of growth they have reached.

A. Place a living specimen in a watch glass in a drop of water and examine with a low power, noting again the body, tentacles, oral cone, foot, and buds if present, and also—

1. That the mouth leads into a central cavity, which, though closed posteriorly, extends into the tentacles, into which food particles freely enter.
2. That the walls of the body and tentacles consist of two layers, an outer layer (ectoderm), and an inner layer (endoderm), which in H. viridis contains chlorophyll granules.
3. The genital sacs, if present, the testes projecting from the body immediately behind the tentacles, and the ovaries from the body near its base.

B. Make a sketch showing the hydra in an extended and in a contracted state, and indicate in the latter sketch all the structures referred to above.

C. Place on a glass slip and examine with a high power, noting—

1. The large ectoderm neuro-muscular cells, with their nuclei, and the processes which form the fibrillated layer between the ectoderm and endoderm.
2. The small interstitial cells lying between the large ectoderm cells.
3. The threadcells (nematocysts), some with the thread still coiled up within the sac, and others with the thread everted. Observe that some of the threads are short, while others are long, and that some of the long threads have three short barbs at their base. If the threads are not visible, a drop of acetic acid usually leads to their eversion.
4. The endoderm cells forming a single layer with delicate processes (cilia) projecting into the body cavity, and with food particles and vacuoles scattered through the protoplasm, and in H. viridis with, in addition, chlorophyll granules.
5. A testis, which when flattened by pressure on the cover glass, is seen to contain ripe or developing spermatozoa. The ripe sperms consist of a head and of a long motile filament, while the developing sperms may either be—(1) in the form of small round granular or hyaline ectoderm cells; or (2) small oval cells with a process growing out from one end to form the filament.
6. An ovary which may contain—(*a*) a number of small round cells; (*b*), a large round nucleated cell, surrounded by small cells; (*c*) a ripe ovum,—a large irregular-shaped amoeba-like cell, with a distinct germinal vesicle and a germinal spot; or (*d*), an ovum in process of segmentation enclosed in a thick capsule.

D. Indicate in an ideal transverse section the ectoderm cells with their thread cells and processes, the interstitial cells between them, and the endoderm cells, with their cilia, vacuoles and granules lying within the fibrillated layer. Indicate also the various stages seen in the development of the spermatozoa and ova, and a segmented ovum if present, within its capsule.

Advanced Students should make and examine transverse sections of the body and tentacles of hardened specimens, in order to study and draw the ectoderm and endoderm cells, their various processes, and the nematocysts.

THE EARTHWORM; *Lumbricus terrestris.*

Observe in a living earthworm the natural movements, and the rows of setæ which subserve locomotion—the four rows of setæ are easily detected by carrying the finger along the ventral surface from behind forwards; the dark dorsal and pale ventral surface and the iridescent cuticle; the clitellum; the small retractile lobe (prostomium) in front of the mouth and the numerous rings (somites) between the mouth and the terminal anal segment.

A. Make a sketch (2 nat. size) of the dorsal surface of the first 40 or 50 segments showing—
- (*a*) The prostomium.
- (*b*) The enlarged segments (29 to 36 inclusive) which form the clitellum.
- (*c*) The dorsal vessel (if visible) running along the median line and the position of the single row of minute dorsal pores.

B. Make a similar sketch of the ventral surface showing—
- (*a*) The mouth between the prostomium and the 1st segment.
- (*b*) The 8 setæ in each segment (except 1st, 2d, 3d, and last)—2 ventral and 2 lateral on each side of the median line.
- (*c*) The clitellum.
- (*d*) The thickening of the epidermis in the region of the inner setigerous glands (8th to 11th segments).
- (*e*) The 4 apertures of the spermathecae—two on each side—between the 9th and 10th and 10th and 11th segments.
- (*f*) The genital openings between the ventral and lateral setæ, (1) of the 2 oviducts in the 14th segment and (2) of the vasa deferentia in the 15th segment.
- (*g*) The openings of the segmental organs (nephridia), some internal and others external, to the ventral setæ,—nephridia absent from 1st and 2d segments.

C. Fix the earthworm with the dorsal surface upwards by one pin through the 1st, and another through the 50th segment, and cover with salt solution. Cut along the middle line from the 25th to the 1st segment, and fix back the skin by introducing pins obliquely through the 3d, 7th, 12th, 16th and 20th segments.

Observe and indicate in a drawing (2 nat. size)—
- (*a*) The mesenteries (intersegmental muscular septa), and the segmental organs in connection with them.
- (*b*) The supra-œsophageal nerve ganglia (3d segment).
- (*c*) The pharynx (1st to 7th segments) œsophagus (8th to 15th segments), and the calcareous œsophageal glands, proventriculus (16th to 17th), gizzard (18th), and the intestine, invested with buff-coloured pigment, extending backwards from the 19th segment.
- (*d*) The bilobed anterior and the usually simple posterior seminal vesicles (9th to 12th segments).
- (*e*) The two pairs of spermathecæ.
- (*f*) The dorsal vessel above the intestine, breaking up into a plexus over the pharynx, and the dilated lateral vessels arching round the intestine from the 8th to the 15th segments.

D. With a pair of fine scissors remove one of the segmental organs. Mount in salt solution, and examine first with low and then with high power, noting and drawing—
- (*a*) The ciliated funnel-shaped opening by which the segmental tube communicates with the body cavity (cœlom), in front of the mesentery.
- (*b*) The narrow portion which pierces the mesentery.
- (*c*) The coiled glandular portion behind the mesentery lined with ciliated epithelium, and surrounded by capillaries in connection with the dorsal and sub-intestinal blood vessels.

E. Examine in salt solution, first with low and then with high power, a portion of a seminal vesicle. Note and draw—
- (*a*) Sperm-polyplasts in various stages of development.
- (*b*) Free spermatozoa—usually better seen in contents of spermathecæ.

F. In the same preparation look for and sketch, if present, the following stages in the life history of the gregarina of the earthworm (Monocystis lumbrici).
- (*a*) Free gregarinæ.
- (*b*) Cysts containing—
  - (1) Two entire gregarinæ or a single gregarina.
  - (2) Gregarinæ partly broken up.
  - (3) Pseudo-naviculæ.

G. After turning the right seminal vesicles to one side and observing the three œsophageal calcareous glands (12th and 13th segments); the lateral blood vessels joining the sub-intestinal vessel; and the pharyngeal plexus formed by the breaking up of the longitudinal vessels; carefully turn aside the portion of the alimentary canal exposed, and fix to the left of the middle line.

1. Examine the nervous system, noting the small nerves running forwards from the supra-œsophageal ganglia towards the prostomium, the lateral commissures passing downwards to the ventral nerve-cord, so as to complete the nerve ring, and the ventral cord formed by a pair of fused ganglia in each segment from the fourth backwards connected by a pair of united commissural cords.
2. Continue the examination of the genital organs, noting at each side of the nerve-cord—
    - (*a*) The two pairs of spermathecæ (between the 9th and 10th, 10th and 11th segments).
    - (*b*) The two small ovaries (one near each side of nerve-cord in 13th segment).
    - (*c*) The oviducts which open internally in 13th segment, and externally through 14th segment.
    - (*d*) The two pairs of small testes (front of 10th and 11th segments), and the seminal ducts which have four rosette-shaped ciliated internal openings (two in the 10th and two in the 11th segment), and two external openings in the 15th segment,—testes only visible when seminal vesicles are small.
3. Make an enlarged drawing (4 nat. size) shewing the genital organs and the exposed portion of the nervous system.

H. Remove the ovary and oviduct from one side, and examine with low power in salt solution.

(1) Sketch the pear-shaped ovary and the ripe and unripe ova in its interior.

(2) Sketch the trumpet-shaped oviducts indicating their wide ciliated internal openings into which the ova find their way on escaping from the ovary.

[illegible] and after fixing [illegible] diagram shewing [illegible] trunks, [illegible] intestinal and [illegible] Remove the worm [illegible]

I. Cut along the middle line from the 25th to the 40th segment, and after fixing the skin at each side, examine the blood vessels. Make a diagram shewing, in a side view, the dorsal, sub-intestinal, latero-neural, and sub-neural trunks, and the lateral branches connecting the dorsal with the sub-intestinal, and the dorsal and sub-intestinal with the sub-neural. Remove the worm from the salt solution and continue the incision along the middle line.

- (*a*) Collect and examine (high power) the perivisceral fluid, noting and drawing the granular amœboid corpuscles.
- (*b*) Cut across the dorsal vessel and examine the blood (high power), noting and drawing the small oval colourless blood corpuscles.
- (*c*) Strip off a small portion of the cuticle from the middle line of the back and examine (high power), noting the row of comparatively large dorsal pores, and the extremely small canals scattered irregularly over the surface, and the fine lines which cause the iridescence.
- (*d*) Examine the setæ from various segments (low power), noting and drawing the modified forms in the region of the clitellum, and in the 10th, 15th, and 23d segments.

J. Examine a prepared transverse section of earthworm—

1. With low power; note and draw—
   - (1) The body wall consisting of (*a*) the structureless cuticle, (*b*) the epidermis, (*c*) a pigmented circular muscular layer, (*d*) a longitudinal muscular layer divided by the setæ into four broad and four extremely narrow bands, (*e*) the parietal layer of cœlomic epithelium.
   - (2) A mesentery (if present) extending between the body wall and the intestine.
   - (3) The alimentary canal, indicating (*a*) the pigmented visceral layer of the cœlomic epithelium, (*b*) the longitudinal muscular layer, (*c*) the circular muscular layer, (*d*) the typhlosole and its blood vessel, (*e*) the dorsal and sub-intestinal blood vessels, and the lateral vessels if present.
   - (4) The nerve cord, and the three vessels in connection with it.
   - (5) The setæ (two lateral and two ventral on each side), the muscles extending from their inner ends to the body wall, and the setigerous glands between the muscular bands.
   - (6) The segmental organs and their apertures internal or external to the ventral setæ.
2. With high power; draw a portion to show—
   - (1) The nucleated cells of the epidermis.
   - (2) Circular and longitudinal muscular fibres of the body wall and intestine.
   - (3) The long granular cells of the visceral layer of the cœlomic epithelium and the ciliated nucleated cells of the intestinal epithelium.
   - (4) The muscular fibres and epithelium of the mesentry, if visible.
   - (5) The nerve cord which consists of (*a*) a muscular sheath, in connection with which are three large fibres, (*b*) nerve fibres, especially abundant in the centre and on the dorsal aspect, and of (*c*) ganglionic cells, which in the ganglia occupy the ventral surface and sides.

Advanced students may further examine the epithelium covering the various organs and lining the body cavity, and the blood vessels in preparations, made from the tissues of a fresh earthworm, treated with ½ p.c. solution of silver nitrate, and mounted in glycerine.

THE MEDICINAL LEECH; *Hirudo medicinalis.*

A. Natural Movements.

Observe that the leech crawls by fixing the anterior sucker as far as possible ahead of the posterior, and then after detaching the posterior sucker by shortening itself, it brings the posterior sucker to within a short distance of the anterior, the posterior having been fixed, the anterior is then detached, and the process repeated. When ascending a vertical surface, note that the body is thrown into a loop by the posterior sucker being fixed immediately behind the anterior. Observe further, that it sometimes completely detaches itself, and after assuming a ribbon-like form swims along in an undulating manner with the dorsal surface upwards when moving in a vertical direction, but with one of the margins usually upwards when moving in a horizontal direction.

B. External Characters.

Note—

1. The dark olive colour of the slightly convex dorsal surface, and at each side of the middle line (*a*) an orange band, (*b*) a similar band interrupted by dark elongated spots, (*c*) a dark, narrow band bordered with orange on the one side and with yellow on the other.
2. On the flattened ventral surface a number of dark patches scattered irregularly over a pale olive ground between two broad dark bands.
3. That the body is made up of a large number of rings, and that the 1st, 2nd, 3rd, 5th, and 8th rings are in some leeches provided with a pair of simple eyes arranged around the anterior end; from the presence of eyes it may be inferred that the 1st and 2nd rings represent the 1st and 2nd segments, the 3rd and 4th, the 3rd segment; and that the 5th, 6th, and 7th rings represent the 4th segment; the segments between the 4th and the posterior sucker are probably made up of 5 rings each, the posterior sucker seems to consist of 7 segments.
4. The anterior sucker formed by the upper lip projecting backwards at each side of the mouth, and the large posterior sucker with the anus lying between its dorsal margin and the last ring—apply the anterior sucker to the skin, and note the presence of the three toothed ridges.
5. On the ventral surface, the penis in the centre of the 24th ring behind the mouth, and the female genital opening between the 29th and 30th rings, the openings, if visible, of the large mucous glands of the 39th, 40th, and 41st rings, and the small apertures of the segmental organs on every 5th ring.

Make a sketch of the dorsal and another of the ventral surface to show the external characters.

C. Dissection.

The leech having been killed with chloroform, should be fixed under water, and an incision carried along the dorsal surface from the third to the second last ring. The skin should then be carefully reflected and fixed with pins at each side of the middle line, in order to expose the alimentary canal and its appendages. In doing this, note the dorsal and the lateral blood vessels and the absence of a distinct body cavity.

1. Examine and draw the digestive tract, indicating—
   (1) The thick-walled tubular pharynx connected by muscular fibres to the body wall.
   (2) The thin-walled stomach with 11 pairs of saccular diverticula (which correspond to the ganglia of the nerve-cord from the 4th to the 14th inclusive), and that the 11th pair of diverticula send long projections backwards towards the end of the body.
   (3) The small tubular intestine running along between the projection of the 11th pair of diverticula to dilate slightly before opening to the exterior between the last ring and the upper margin of the posterior sucker.
2. Indicate in the same sketch, the position of the dorsal and lateral blood vessels—the remains of the reduced body cavity.
3. Examine (high power) the blood (which is coloured with hæmoglobin) for the colourless corpuscles.
4. Make an incision along the pharynx, stomach, and intestine, and note—
   (1) The position of the circular muscles which on contraction close both ends of the fusiform cavity, and the muscles which radiate to the skin, and serve for producing the sucking action, and also the longitudinal folds containing muscular fibres which serve for driving the blood backwards into the gastric diverticula.
   (2) That the stomach is constricted by incomplete septa, which extend inwards between the diverticula, and that communicating by a small aperture with the pharynx in front, it projects slightly into the intestine behind.
   (3) That the gastric diverticula consist of a small anterior and of a larger posterior chamber, the posterior chamber of the 11th extending, as already seen, nearly to the end of the body.

5. Cut across the pharynx near its centre, and the intestine near its termination, and carefully remove the intestinal tract, in order to expose the blood vessels, nervous system, and the reproductive and segmental organs.

Observe—

(1) The ventral blood vessel enclosing the nerve cord and sending branches to communicate with the lateral blood vessels.

(2) The segmental organs (17 pairs corresponding to the 2d to the 18th ganglia inclusive) consisting of convoluted tubes in connection with rounded vesicles.

(3) The 9 pairs of testes (corresponding to ganglia 8 to 16 inclusive) with their ducts opening into the two vasa deferentia, and that the vasa deferentia become convoluted to form the large vesiculæ seminalis which communicate with the penis—the penis lies in a bent sheath which, springing from a large sac, opens through the 24th ring behind the mouth.

(4) The 2 small ovaries lying in the segment behind the vesiculæ seminalis, which communicate by slightly twisted oviducts with a muscular uterus—the uterus opening to the exterior between 29th and 30th rings behind the mouth.

(5) The 4 mucous glands, if visible, lying behind the ovaries.

(6) The nerve cord extending backwards from the œsophageal ring to end in a large ganglion lying above the posterior sucker. Noting—

  (*a*) The two supra-œsophageal ganglia giving off 5 pairs of optic nerves and communicating with the 3 small buccal ganglia which lie one above and one at each side of the buccal cavity.

  (*b*) The commissures connecting the supra-œsophageal ganglia with the sub-œsophageal ganglion, which is made up by the fusion of 3 or 4 embryonic ganglia, and from which several (4) pairs of nerves extend to the surrounding tissues.

  (*c*) The 2d to the 21st post oral ganglia, each giving off 2 pairs of nerves, the 22d ganglion giving off only 1 pair of nerves, and the 23d (made up of 6 or 7 embryonic ganglia) giving off 7 pairs of nerves.

(7) Examine with a low power and sketch a portion of the double nerve cord lying in the ventral blood vessel, and one of the ganglia with its lateral branches.

(8) Make a drawing, showing (*a*) the ventral and lateral blood vessels, (*b*) the nephridia, (*c*) the generative organs and the nervous system.

6. Examine the buccal cavity, noting the Y-shaped oral aperture, and the toothed ridges which lie on the inner surface of the three lobes formed by the strong buccal muscles.
7. Remove one of the toothed ridges, examine (low power), and sketch.
8. Advanced students should prepare and
    (1) Examine (low power), and afterwards sketch transverse sections—
        (i) Through the middle of the body, showing (*a*) cuticle ; (*b*) epidermis and dermis, containing capillaries and simple glands ; (*c*) external circular, longitudinal, internal circular, radiating and dorso-ventral muscular fibres; dorsal, lateral, and ventral blood vessels; and the nerve cord or ganglia ; (*d*) the stomach and its diverticula ; (*e*) the nephridia, testes, and vasa deferentia.
        (ii) Through the anterior end of the body, noting (*a*) the ocelli, closed capsules containing large transparent cells ; (*b*) the nerve cells of the supra-œsophageal ganglia ; (*c*) the cup-shaped glands in the epidermis.
    (2) Examine (high power) (*a*) one of the ovaries teased in salt solution, and sketch several ova ; (*b*) one of the testes prepared in the same way, and draw the spermatozoa ; (*c*) one of the ganglia teased in carmine or picro-carmine, and sketch the ganglion cells.

THE STAR-FISH; *Asterias rubens.*

Observe in the living star-fish the natural movements. Notice that locomotion is effected by the pedicels or tube feet on the under (oral) surface of the rays, these pedicels having suckers at their tips, whilst the terminal pedicels of the rays are unprovided with suckers, and act as tentacles.

Turn the star-fish on its aboral surface and observe how it twists round the tip of one or more of its rays until the pedicels situated there can be attached, the pedicels further back being then applied by a similar and progressive twisting of the ray, until by this spiral-like movement the disc is drawn over.

A. Make a sketch (natural size) of the slightly convex aboral surface, showing the central pentagonal disc with the five rays radiating from it; the whitish circular madreporic tubercle placed towards one side of the disc and opposite the point of junction of the two rays which form the *bivium*; the minute anal opening placed slightly to the left of an imaginary line from the tubercle to the tip of the opposite ray; the calcareous ossicles bearing short spines embedded in the soft tissue of the integument, and the short stems bearing pincer-like heads—the pedicellariæ.

Remove one of these pedicellariæ, examine with low power and draw.

B. Sketch the flat oral surface, showing—
- (*a*) The large central mouth.
- (*b*) The five ambulacral grooves running along the oral faces of the rays.
- (*c*) The two double rows of pedicels nearly filling these grooves.
- (*d*) At the tip of each ray the small red eye spot.

C. 1. Remove and examine under low power one of the pedicels, noting the sucker-like tip strengthened by five or six calcareous plates.

2. Examine also a pedicel from the tip of the ray, and notice that it is not terminated by a sucker.

3. Pull off carefully the pedicels from a portion of one of the rays, and notice the radial nerve extending along the centre of the ambulacral groove to end in the eye-spot.

D. Fix the star-fish, mouth downwards, under water. Select the ray furthest from the madreporic tubercle, and cut through the skin along each side of the ray from the base to the tip; dissect off this strip of skin, and make a drawing of the organs exposed, viz.:—

- (*a*) The two large brown sacculated hepatic cæca lying along nearly the whole length of the ray on each side of the ambulacral plates;—notice that near the base of the ray each cæcum ends in a delicate tube; and that the two tubes unite to form a single hepatic duct which opens into the large membraneous pyloric sac of the stomach.
- (*b*) The stomach, with its eversible cardiac pouches projecting into each ray below the hepatic duct;
- (*c*) The two reproductive glands, the duct from each passing into the side of the inter-radial partitions, where it joins with that from the next ray to open to the exterior in the angle between the rays.

E. Reflect the skin from the central disc, taking care not to injure the madreporic tubercle, and sketch—

- (*a*) The stomach, with its cardiac and pyloric sacs.
- (*b*) The short intestine near its centre.
- (*c*) The rectal glands opening into the intestine.
- (*d*) The retractor muscles of the cardiac pouches.
- (*e*) The short œsophagus.

F. Remove the pyloric cæca and reproductive organs carefully from the dissected ray, and examine and sketch the ampullæ of the pedicels. Scrape off some of these, and notice that the pores for the pedicels are placed between the ambulacral ossicles and alternately near the base and near the ridge, appearing to be in two rows though forming only a single irregular one.

G. Cut transversely through the ray, and sketch—

- (*a*) The ambulacral ossicles sloping up to meet in a ridge at the centre, and forming the ambulacral groove.
- (*b*) The small plates—interambulacral plates—on which they rest.
- (*c*) The inter-radial septa formed by junction of the inter-ambulacral plates of adjacent rays.
- (*d*) The cut section of the radial water tube lying below the ridge formed by the ambulacral plates.
- (*e*) The radial blood-vessel lying below the water-vessel.
- (*f*) The radial nerve lying external to the blood-vessel.

Dissect out carefully the stone canal which extends from the madreporic tubercle to the circum-oral water tube; trace one of the radial water vessels to the ring, and notice the sinus running parallel to the stone canal, and opening into a circular vessel beneath the water ring, from which spring the radial blood-vessels.

THE SEA URCHIN; *Echinus esculentus.*

A. Observe the natural movements of the living animal, noticing that it uses for locomotion not only the pedicels or tube feet, like the star fish, but also the spines which cover the test; and that on a flat surface it uses its teeth also for this purpose, by projecting them and pushing itself over them. Touch any part of the test, and observe that the adjacent spines and pedicellariæ all converge to the point of stimulation, the pedicellariæ attempting to grasp the irritating object.

B. Make a drawing of the sea urchin from the side, indicating:—The spheroidal form; the small tubercles bearing movable spines; the five ambulacral areas perforated for the pedicels, and the five inter-ambulacral areas between them. Notice that the ambulacral areas are wide where they commence at the mouth, and narrow towards the aboral region.

C. Scrape off the spines from a small portion of both areas, and sketch—
(*a*) The double row of plates in each area bearing the tubercles, which are of various sizes, and bear corresponding sized spines.
(*b*) The perforations in the ambulacral plates for the pedicels.

D. Scrape off a few of the spines in the aboral region, and indicate the arrangement of the plates exposed:—
(*a*) The five genital plates perforated for the genital ducts, one of them larger and rougher than the others serving as the madreporic tubercle.
(*b*) The five smaller ocular plates placed between the genitals—one at the apex of each ambulacral area.
(*c*) The central semi-membraneous area surrounded by the genital plates, and perforated by the anal opening.

E. Sketch the oral surface, showing the large membraneous area with the mouth, occupied by the five teeth in the centre; and the five pairs of tentacles projecting from the sinuses which surround the lantern.

F. Remove, examine (low power), and draw the following structures:—
(*a*) One of the spines, indicating its fluted appearance and the cup or socket at its base surmounted by a ridge with muscular fibres adhering, which held the spine in contact with the tubercle on the surface of the test.
(*b*) Several of the pedicellariæ,—noting that they consist of a long slender stem, partly calcareous and partly membraneous, and of a head made up of three movable mandibles.
(*c*) One of the pedicels with its sucker-like tip containing five or six calcareous plates.

G. Cut with a pair of scissors round the "equator line" of the echinus, and separate the two halves without tearing across the intestine, and lay the upper portion beside the lower with aboral surface downwards. Make a sketch showing—

(*a*) The dentary apparatus, or Aristotle's Lantern.
(*b*) The alimentary canal passing from the lantern and coiling round the test, to terminate in the centre of the aboral region.
(*c*) The generative organs hanging in lobes from the test around the anal aperture, and opening by five ducts to the exterior.
(*d*) The stone canal which passes from the madreporic tubercle in a direct central line to end in the water ring surrounding the œsophagus.
(*e*) The polian vesicles.
(*f*) The five radial water vessels which pass down outside the alveoli to reach the ambulacral area.
(*g*) The pedicels springing from the radial vessel, and the ampullæ formed on the tube which projects into the test from the bases of the pedicels.
(*h*) The membraneous sinus which runs alongside the upper part of stone canal.

H. Sketch the dentary apparatus in position from the side and from above, showing—

(*a*) The five pairs of long triangular alveoli connected by interalveolar muscles.
(*b*) The teeth lying between the alveoli.
(*c*) The radii extending across the base of the lantern.
(*d*) The rotulæ articulating at their outer ends with the alveoli, and at their inner with the radii.
(*e*) The transverse muscles connecting the radii.
(*f*) The protractor muscles extending from the top of each alveolus to the interambulacral areas.
(*g*) The retractor muscles extending from the oral ends of the alveoli to the auricles.

I. Cut away carefully with scissors the tips of the alveoli on one side of the lantern, to expose the pentagonal ridge, which forms the nerve ring, on the inner surface of the oral membrane. Trace the radial nerves from the nerve pentagon along the ambulacral areas to their termination in the eye-spots on the ocular plates.

J. Remove a portion of the nerve cord and examine with the microscope (low power), noting the lateral branches, and also the radial water vessel and its lateral prolongations.